Nature and Properties of Waves

PS-7 The student will demonstrate an understanding of the nature and properties of mechanical and electromagnetic waves.

PS-7.6 Summarize reflection and interference of both sound and light waves and the refraction and diffraction of light waves.
Taxonomy Level: 2.4 B Understand Conceptual Knowledge

Key Concepts:
Wave behaviors: Reflection, Refraction, Diffraction
Constructive interference, Destructive interference
Concave lens, Convex lens
Law of reflection, Plain mirrors

Previous/Future knowledge: In the 8th grade students summarized the behaviors of waves (including refraction, reflection, transmission, and absorption) (8-6.4); explained hearing in terms of the relationship between sound waves and the ear. (8-6.5); explained sight in terms of the relationship between the eye and the light waves emitted or reflected by an object (8-6.6); and explain how the absorption and reflection of light waves by various materials result in the human perception of color (8-6.7). In Physical Science the students will expand the ideas of reflection and refraction of light and reflection of sound. The students will be introduced to the ideas of constructive and destructive interference of sound and light waves. The students will also be introduced to the concept of diffraction of light waves.

It is essential for students to
- Understand that waves can interfere with each other when they pass through a medium simultaneously. The result of the combination of the waves when they pass through the medium simultaneously can show constructive and/or destructive interference.
  - Interference may be *constructive*:
    - A crest will interfere with another crest constructively to produce a larger crest and a trough will interfere with another trough to produce a larger trough.
    - Compressions interfere constructively with each other as do rarefactions.
  - Interference may be *destructive*:
    - A crest will interfere with a trough to lessen or cancel the displacement of each.
    - Compressions interfere with rarefactions to lessen or cancel the displacement of each
  - The individual waves are not affected by the interference and will continue on as if nothing has happened.

Sound waves
It is essential for students to
- Understand that sound is a longitudinal mechanical wave, requires a medium, and can be produced by vibrating objects.
- Understand that sound, like other waves, *reflects* (bounces off a surface it cannot go through). Sound produces echoes when it bounces off hard surfaces.
- Understand that sound waves *interfere* with each other changing what you hear.
  - Destructive interference makes sounds quieter; constructive interference makes sounds louder. This is because amplitude of a wave is what is affected by interference and a sound wave's amplitude is heard as loudness.
  - Sound waves reflect in tubes or some musical instruments to produce standing waves which reinforce sound through constructive interference to make the sound louder.

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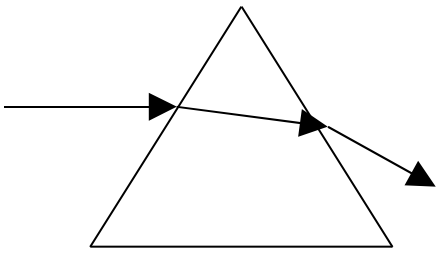
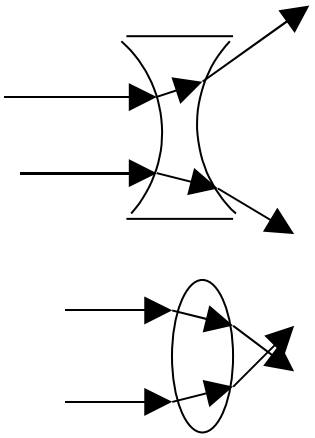
Light waves

It is essential for students to

- Understand that light waves *reflect*:
  - When light rays reflect they obey the "*Law of Reflection*". The angle of incidence is equal to the angle of reflection.
    - The angle of incidence is the angle between the incident ray and a line normal (perpendicular) to the surface at the point where the light strikes.
    - The angle of reflection is the angle between the reflected ray and the normal line.
- Understand that light waves *reflect in plain mirrors* to produce images.
  - The image appears as far behind the mirror as the object is in front of it.
  - The image and the object appear to be same size.
  - The image is upright.
- Understand that light, like other waves, can *diffract.*
  - *Diffraction* is the bending of a wave around a barrier or around the edges of an opening.
    - Waves with a longer wavelength diffract more readily. In order to observe light diffraction the barriers or openings must be small.
    - When light waves diffract interference patterns can often be observed.
- Understand that light waves can *interfere* to produce interference patterns.
  - Light waves can interfere constructively and destructively.
    - When light waves interfere, a pattern is often seen with light and dark areas created by constructive and destructive interference. The amplitude of a light wave is observed as brightness. Brighter areas show constructive interference and darker areas show destructive interference.
    - At other times light waves interfere to produce a color pattern. When a color of light interferes destructively, we will not see that color. We will see the colors that are not interfered with destructively.
  - Light waves can reflect off the bottom and top surfaces of thin film, such as oil on water or bubbles, and produce a color pattern due to interference.
  - Light wave can diffract through small slits or around lines to produce light and dark patterns or color patterns due to the interference of light waves.
- Understand that light, like other waves, can *refract*.
  - Waves refract when they change direction upon entering another medium. In order to refract the wave must:
    - Change speed when it hits the new medium and
    - The wave must strike the new medium at an angle other than perpendicular.
  - Light waves refract when they enter a different medium at an angle other than perpendicular and change speed.
  - Students should be able to predict the way that the light rays will bend.
    - In the diagram at the right, light slows down when it enters the prism and bends down when it strikes at this angle.
    - When light exits the prism at the right, it speeds back up and bends down again.



- When white light enters another medium such as a prism and refracts the colors may spread out. This is because the violet end of the spectrum slows down more than the red end and therefore bends more.
- Lenses may be a concave (diverging) lens or convex (converging) lens.
- Students should be able to draw the resulting rays as light passes through each type of lens.



It is not essential for students to

- Understand the distance an object must be placed to produce certain images with different types of lenses or mirrors or the sizes of those images;
- Understand concave and convex mirrors;
- Understand focal length;
- Understand that light waves form real or virtual images of different sizes when passing through lenses;
- Understand how sound waves are made by musical instruments.

Assessment Guidelines

The objective of this indicator is to *summarize* the concepts of reflection, refraction, diffraction and interference for light waves and reflection and interference for sound waves, therefore, the primary focus of assessment should be give major points about these wave behaviors related to light and sound waves.

In addition to *summarize*, assessments may require that students

- *Compare* the behavior of light waves in different situations of reflection or refraction;
- *Infer* how light waves reflect, refract or interfere;
- *Infer* what will be heard when sound interferes or reflects;
- *Exemplify* behavior of light or sound waves in different situations or effects of that behavior;
- *Illustrate* light wave behavior when it encounters concave or convex lenses or a prism.